Analysis of the Value of Front-of-the-Meter Distributed Wind in New York*

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Abstract

This work explores the value of front-of-the-meter (FOM) distributed wind in the context of the state of New York. In particular the analysis looks at the value of FOM distributed wind relative to behind-the-meter (BTM) wind and utility-scale wind. The analysis uses the New York Public Service Commision's (NYPSC) Value of Distributed Energy Resource (VDER) framework in combination with CoreLogic's parcel-level dataset to determine the value of exports from distributed wind energy throughout the state of New York in high geospatial and temoporal resolution.

Keywords: distributed wind, front-of-the-meter, behind-the-meter, New York, VDER, Value of Distributed Energy Resource, GIS, slow trains, Alabama, pins, pin-dropping, Bluth, banana stand

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Results to add:

- are there any adaptations in VDER necessary for distr. wind?
- what vder values drive wind?
- where is the potential concentrated and why?

Figures to add:

- wind resource map as seen in ES of [13].
- fix maps to include municipal utility territory and merge con edison territory

Introduction notes:

- talk about Ben/Kevin's paper McCabe, Sigrin, Lantz and Mooney [13].
- more background into value of solar Denholm, Margolis, Palmintier, Barrows, Ibanez, Bird and Zuboy [6]
- more background into NY
- differentiating between different sizes of distributed wind
- this paper differs from previous dGen analyses as it does not consider future developments/progressions, but only a snapshot of a single year analysing all sites, not just economic ones

Bringing together techno-economic potential, granular compensation mechanisms and distributed wind:

1. bass diffussion curve basics (starts in small pockets, then spreads to general public).
2. more granular analysis can help identify in few pockets where distr. wind profitable
3. solar provides a marginal benefit as it exhibits coincident generation
4. granular compensation mechanisms based on value to system can reward select pockets of wind and
5. are more likely to trend towards rewarding non-solar resources as power system saturates (assumes no measures taken to shift solar energy or demand)

1. Introduction

1.1. *Current Status of Distributed Wind Nationally*

Distributed wind generators can be defined as relatively small-scale turbines in the range of a few kilowatts [kW] to few megawatts [MW] that are interconnected to the power system at the distribution level, either as front-of-the-meter or behind-the-meter installations [1]. From 2008 to 2018, distributed wind capacity in the United States has grown steadily from 310 MW to 1,127 MW [22]. Distributed wind installations are influenced both by resource availability and by policy initiatives and several states have dominated the distributed wind market in the past decade. For instance, Texas [191 MW], Iowa [187 MW], Minnesota [136 MW], Massachusetts [80 MW] and California [75 MW] account for approximately 60% of cumulative installed capacities for distributed wind in the United States [22].

break down distributed wind deployment by size categories!

The distributed wind market, however, is completely overshadowed by utility-scale wind, which grew from 25, 065 MW to 96,433 MW in the same 2008 to 2018 time period [26]. Distributed wind has also been surpassed by distributed solar PV, which grew from 582 MW_{DC} in 2010 to 4,637 MW_{DC} in 2018 [3]. In 2018, distributed wind added only 50.5 MW of capacity while utility-scale wind added 7,588 MW and distributed solar PV added 4,637 MW_{DC}. The cumulative capacity and annual capacity additions for distributed wind, utility-scale wind and distributed solar PV are shown in Figure 1.

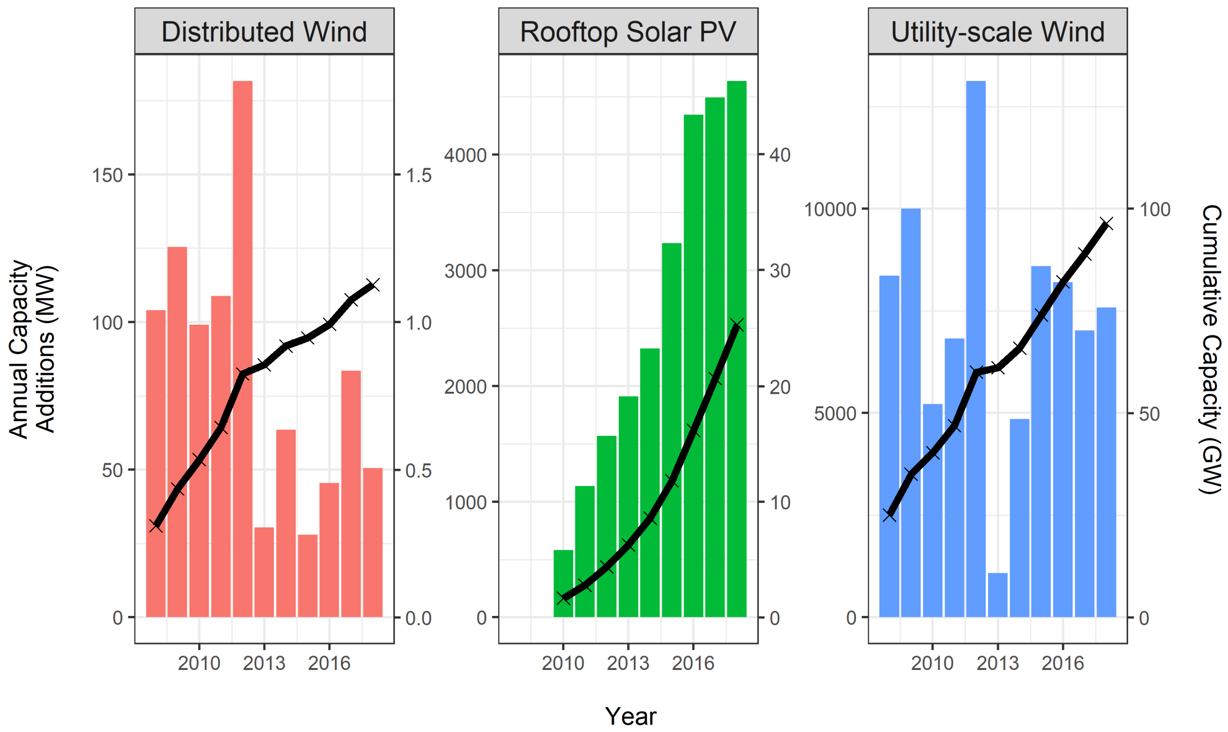


Figure 1: Cumulative Capacity and Annual Capacity Additions of Distributed Wind, Distributed Solar PV and Utility-Scale Wind in the United States, 2008-2018

The wide disparity in capacity growth between distributed wind and both utility-scale wind and distributed solar PV has generated interest in evaluating the technical and economic potential for the distributed wind industry. Technical potential is defined here as the achievable electricity generation capacity (MW) of a technology given information about an area's geographic or technology-specific constraints. Technical potential reflects the fact that not all physically available resources are developable, due to constraints to siting generation systems in particular areas (such as overhead canopy, obstruction of buildings, etc.) [10]. Economic potential is defined here as a subset of the technical potential for economically viable generating capacity. Economic potential quantifies the generating capacity of systems capable of earning a positive net present value at a given point in time and reflects that fact that not all sytems which can technically be built will earn enough over their lifetime to offset the initial capital costs or recurring fuel and operation and maintenance costs associated with their generation [13]. Figure 2 shows the connection between underlying physical resources and technical and economic potential.

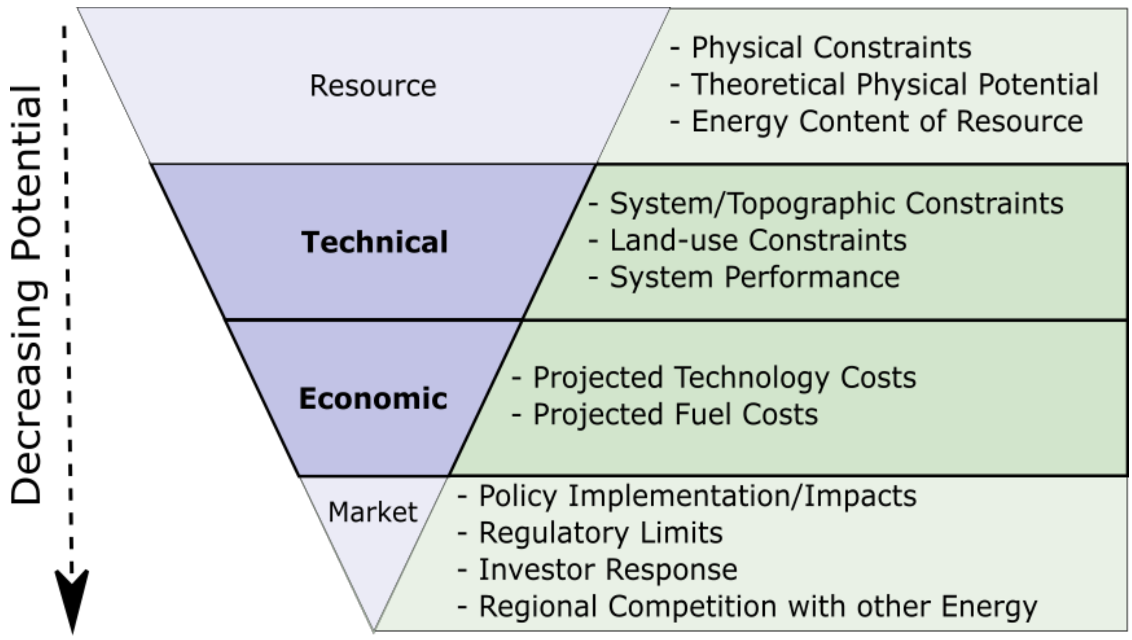


Figure 2: Framework Assessing Renewable Energy Potential and Associated Considerations. Adapted from [11]

Previous research has sought to evaluate the potential of distributed wind within select geographic regions, such as McCabe, Sigrin, Lantz and Mooney [13] which analyzed the economic potential for distributed wind in Colorado, Minnesota and New York. Ramdas, McCabe, Das and Sigrin [24] likewise evaluated how the economic potential for distributed wind in California would be impacted by planned changes to the retail tariff as customers were shifted to time-of-use rates. MORE STUDIES ON DISTRIBUTED WIND CAPACITY. This paper seeks to evaluate the technical and economic potential for distributed wind in the state of New York relative to utility-scale wind and distributed PV. In 2018 New York added 200 kW of distributed wind, bringing the state's cumulative capacity to 13.2 MW, compared to 1,987 MW of cumulative utility-scale wind and 434.3 MW_{DC} of distributed solar PV [3, 22, 26]. The state was chosen as it was an established (if not leading) distributed wind market with promising resource potential and welcoming policy environment.[3]

In addition to favorable resources, New York has a highly granular compensation mechanism to reward exports of energy from distributed resources depending on the time and location of the export.

1.2. Diffusion of New Technologies and its Relation to Distributed Wind

The diffusion of new distributed generation technologies is characterized by adoption among small pockets of the general public. For these customers, due to unique characteristics such as specific demand patterns, unique tariffs, higher than average utility bills, access to unique policy support, or personal opinions on clean generation, the costs associated with the distributed generation resource are outweighed by the economic and non-economic benefits of the technology before the general public. As these initial customers begin adopting the technology, it helps establish the market, which grows according to an "S-curve" as more and more customers begin consider the technology given its new visibility and lower prices (see Figure 3) SOURCE. While Bass diffusion models can adequately explain the adoption of distributed assets from a customer perspective, front-of-the-meter (FOM) distributed assets can be driven by slightly different processes SOURCE.

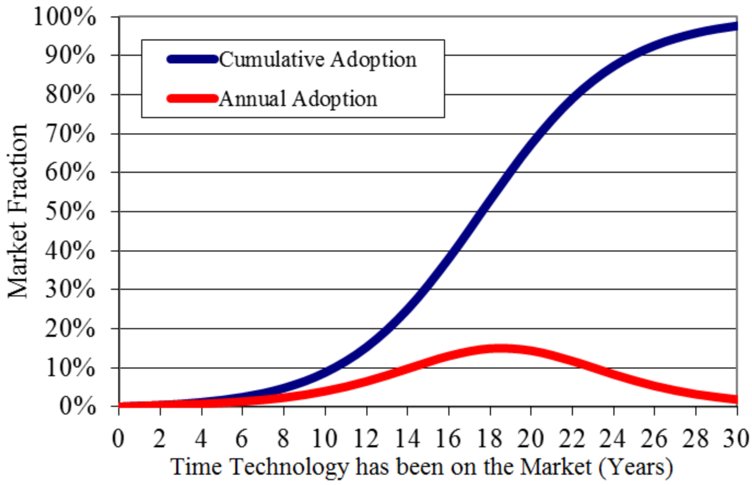


Figure 3: Annual and cumulative adoption rates simulated using the diffusion of innovations framework. Source: Sigrin et al. [25]

For FOM assets, utilities may evaluate the ability of the resource to provide a unique set of services inaccessible to utility-scale assets, due to factors such as transmission constraints SOURCE. However, even though the adoption of these resources is not driven by

[3]Although currently expired, the Small Wind Incentive Program, administered by the New York State Energy Research and Development Authority (NYSERDA), offered up to 50% rebates of the total installed costs for distributed wind generators (up to 2 MW in capacity) from 2016 to 2018 [20].

individual customer decisions, the diffusion model can still accurately describe the trajectory of adoption as deployments are initially constrained to a small portion of the power system with the most advantageous conditions, but later expands to other parts of the grid as technology costs come down, driven partly by initial diffusions establishing a market THIS WHOLE PARAGRAPH IS SUSPECT AND NEEDS TO BE THOROUGHLY REVIEWED AND REWRITTEN. Whether customer-driven behind-the-meter deployments or utility-driven front-of-the-meter deployments, initial markets can be constrained to a small number of locations/applications/conditions. Identifying these limited locations/applications/conditions can help customers and utilities invest in economic deployments as well as help policymakers kickstart local markets through targeted incentives or other measures.

This identification, however, requires a sufficiently granular analysis as averages, whether of wind resources, tariff structures, siting availability or otherwise, can hide pockets in which conditions are sufficient to warrant investment in a given technology. Furthermore, in analyzing the potential adoption of a front-of-the-meter system by a utility, there must be a way to accurately monetize the many potential benefits such a system could accrue to the power system and utility as these economics are what is ultimately compared to technology costs when deciding whether or not to adopt. The 'Value of Distributed Generation' framework provides a useful methodology of quantifying the benefits of a distributed resource's exports that accrue to the the power system [6].

1.3. The Value of Distributed Energy Resources

In the aftermath of Hurricane Sandy, the New York Public Service Comission (NYPSC) proposed the Reforming the Energy Vision (REV), a fundamental overhaul of the regulatory and market structures surrounding the distribution system to address issues as diverse as concerns over carbon emissions, aging infrastructure and growing physical and cyber threats to the power system [17]. As part of the REV initiative, NYPSC developed a new mechanism to compensate exports from distributed energy resources such as rooftop PV and distributed wind generators. The mechanism, called the Value of Distributed Energy Resources (VDER) is intended to ultimately replace the current compensation mechanism of net energy metering (NEM) [18].

Under net energy metering, a customer is only billed for their net energy consumption (i.e. what the customer consumes less their exports to the grid), essentially rewarding a customer's exports at the retail rate of electricty [27]. Net energy metering is a widely adopted compensation mechanism for distributed generation in the United States [23]. Net energy metering, depending on the underlying retail tariff, is a farily invariant compensation mechanism that rewards exports to the grid at a flat rate regardless of the time of the injection of energy or of the underlying local grid conditions where the power is injected. Thus, NEM does not attempt to reward exports according to their value to the power system and concerns have been raised that this lack of accurate price signals can lead to cross-subsidization SOURCE. Furthermore, without adequate price signals, neither the deployment nor operation of these distributed generators can be aligned with power system needs, as customers, who tyically operate their systems to minimize their electricity bills, have little incentive or information to adjust their behavior SOURCE.

In response to these concerns, and in response to higher penetrations of distributed generation, many stakeholders have begun reevaluating how distributed generation should be compensated [23]. One alternative compensation mechanism that has emerged is a Value of Distributed Generation framework, which attempts to quantify the value of an injection of distributed generation to the power system (or other stakeholders), often in high temporal and geosptial granularity [6]. The values expressed/explored/rewarded under these frameworks vary from jurisdiction to jurisdiction, depending on their relative importance, as do the methods pursued to quantify the magnitude of the values. Some common values explored include: 1) Energy; 2) Environmental; 3) Transmission and distribution losses; 4) Generating capacity; 5) Transmission and Distribution capacity [23].

The energy benefits associated with distributed generation represent the ability of the distributed system to offset generation from more expensive variable cost generators on the margin,[4] which reduce their output in response to the distributed generation. The environmental benefits are closely related to the energy value, and typically represent the reduced environmental costs (e.g., pollution) associated with the generators on the margin who reduce their output. Distributed generation can help avoid transmission and distribution losses as it is typically sited closer to load than utility-scale generation (ENOUGH??. The generating capacity benefits of distributed generation represent the ability of distributed generation to help meet peak demand, which can reduce the amount of additional utility-scale generating capacity which must be procured to meet growth in peak demand. Similarly, distributed generation can help reduce congestion on portions of the power system or reduce the need for additional transmission capacity by meeting demand locally [6].

[4] on the margin means ...

2. Methodology

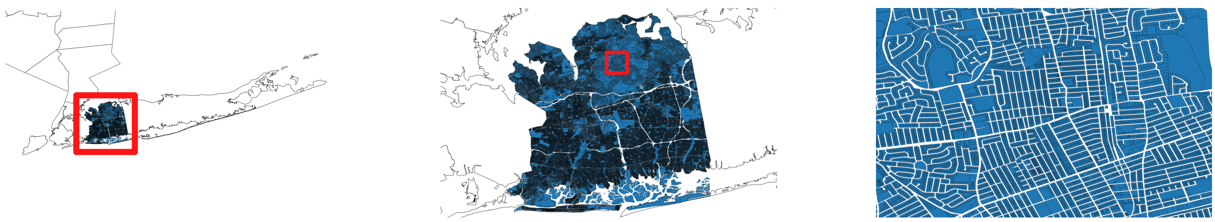
This analysis addresses the availability and overall estimated value of behind-the-meter (BTM), front-of-the-meter (FOM) and utility-scale wind throughout the state of New York. In this analysis, whether a wind turbine was deployed as BTM, FOM or utility-scale is referred to as its ‘application’. This analysis considered a range of turbine classes (sizes and hub heights) available for deployment, although some turbine classes were considered too small or too large for certain applications. In addition to size constraints, the eligibility for certain applications was influenced by characteristics of the parcel of land on which the turbine would be deployed. These characteristics include: available parcel land area, canopy cover, and land-use type. Once a turbine’s siting, sizing and application eligibility had been determined, its generation was determined using wind resource data and power curves. Finally, given the turbine’s generation, application and location within a utility territory and load zone, the appropriate values from the VDER framework were calculated.

The following sections address:

- how wind turbines were sited within New York, including which metrics were used to determine siting availability;
- how the sizes of the wind turbines were determined;
- how generation profiles for the wind turbines were determined;
- how costs associated with building, maintaining and operating the systems were determined; and
- how values from the VDER framework were ultimately derived.

2.1. Turbine Siting

This analysis takes advantage of an exceedingly granular, proprietary parcel-level data set referred to throughout this report as the CoreLogics data set. ‘Parcel-level’ refers to the fact that the minimum unit under consideration for siting a wind turbine were individual parcels as opposed to states, census blocks or zip code areas. The granluarity of this data set can be seen in Figure 4.



(a) Zoomed-out view of Long Island

(b) Zoomed-in view of Portion of Long Island

(c) Zoomed-in View Highlighting Individual Parcels

Figure 4: Multiple-scale view displaying the geospatial granularity accesible in the CoreLogics parcel data set.

The information provided in the CoreLogics data set includes, among other information:

- the ‘land use type’ (e.g., hospital, quick service restuarant, etc.);
- the total land area of parcel;
- blah;
- blah;
- blah.

In addition to sizing limitations on the application of wind turbines, some land-use types were considered incompatible with certain applications (e.g., residential land use types were considered unlikely to host utility-scale projects while ‘forest’ and some agricultural land use types were considered to be incompatible with behind-the-meter applications). Although these land use type exclusions are subjective, a machine-learning approach will be considered for the final report in September. Table A.1 in Appendix A shows all of the land use types considered in this analysis along with the eligible applications for that land use type and the assumed load pattern used with the land type. Load patterns are used to determine the value of the distributed generation for behind-the-meter applications under the VDER and NEM frameworks (see Section 2.5).

2.2. Turbine Sizing

Wind turbines considered in this analysis for behind-the-meter, front-of-the-meter and utility-scale installations rely on mulitples of discrete turbine sizes as opposed to a continuous selection of wind turbines. Each turbine size is associated with a specific set of available hub heights. Furthermore, not all turbine sizes are available for all types of installations to reflect the fact that some turbines are simply too large to realistically be deployed behind-the-meter or too small to be deployed at the transmission-level (utility-scale). These hub-height and turbine sizes are shown below in Table 5 and are based on the original dGen turbine sizes. The assignment of certain sizes to specific applications is based on turbine classifications in [25]. table classifications just placeholders!

turbine size == rated capacity

Any individual parcel may be subject to development constraints based on local siting conditions. In this analysis the primary siting constraints for wind turbine sizing are around available parcel size and canopy density and height similar to the basic dGen model assumptions [25]. As there are over Forty Bajillion parcels considered within the state of New York for this analysis, the available parcel size is simply taken to be the area of the given parcel less the footprint area of buildings within the parcel, assuming any are present. Considerations over the largest contiguous area available to develop a wind turbine are ignored as are considerations over the shape of the undeveloped space within a parcel. The total parcel area is given within the CoreLogics dataset while the building footprint area is determined from the Microsoft Blah Blah dataset. Each of the turbine hub heights defined above in Table 5 are associated with a mimum available parcel size, outlined below in Table 6.

Table B5 of Sigrin, Gleason, Preus, Baring-Gould and Margolis [25] - is percent of highly-developed land considered in this analysis??

			Hub Height (m)				
Application	Turbine Size Class	Turbine Size (kW)	20	30	40	50	80
Behind-the-meter	Small (Residential)	2.5	✓	✓	✓		
Behind-the-meter	Small (Residential)	5		✓	✓		
Behind-the-meter	Small (Residential)	10		✓	✓		
Behind-the-meter	Small (Residential)	20		✓	✓	✓	
Behind-the-meter	Small (Commercial)	50		✓	✓	✓	
Behind-the-meter	Small (Commercial)	100			✓	✓	
Front-of-the-meter	Midsize	250				✓	
Front-of-the-meter	Midsize	500				✓	✓
Front-of-the-meter	Midsize	750				✓	✓
Front-of-the-meter	Large	1000				✓	✓
Utility-scale	Large	1500					✓

Figure 5: Wind Turbine Configurations Included in the Analysis Source: Sigrin et al. [25].

Turbine Hub Height (m)	Minimum Parcel Size (acres)
20	0.50
30	1.00
40	2.00
50	3.00
80	4.00

Figure 6: Minimum Parcel Size Required for Each Available Hub Height. Source: Sigrin et al. [25].

In addition to available parcel sizes, tree canopy cover can also impact the maximum turbine size available to site a wind turbine within a given parcel. Similar to considerations outlined in [25], parcels with less than 25% average canopy cover are defined as "low canopy density" areas and are not assigned any additional turbine sizing constraints. Parcels above this threshhold are considered"high canopy density" areas and are subjected to additional constraints based on the average canopy cover height in the given parcel. Wind turbines in these "high canopy density" parcels must have a certain clearance above the tree cover, based on the size of the turbine rotor (Table 7). Tree canopy density has been determined using a high-resolution (30-m by 30-m) grid of percentage of canopy cover included in the National Land Cover Data set 2011 (NLCD) [8]. Average canopy cover height has been determined using the high-resolution (30-m by 30-m) National Biomass and Carbon Data set [9].

need to explain all this canopy business better

2.3. Turbine Generation Characterization

Wind generation in this analysis is a function of the available underlying resource, the wind speed at the corresponding hub height, and the power curve of the corresponding

Turbine Size (kW)	Approx. Rotor Radius (m)	Required Clearance (m)
2.5	2.2	17.20
5.0	3.1	18.10
10.0	4.4	19.40
20.0	6.2	21.20
50.0	9.8	24.80
100.0	13.8	28.80
250.0	21.9	36.90
500.0	30.9	45.90
750.0	37.8	52.80
1,000.0	43.7	58.70
1,500.0	53.5	68.50

Figure 7: Canopy Clearance Required for Each Turbine Size (i.e., Rated Capacity). Source: Sigrin et al. [25].

turbine. The hourly averge wind speeds at various hub heights for the typical meteorological year (TMY) at a medium resolution (20-km by 20-km) were provided in the AWS TruePower data set [4]. These 20 km blocks are further resolved into 200m blocks using the methodology described in [25, Appendix B2]. Wind speeds at hub heights not available in the AWS TruePower data set are calculated using wind speeds at available hub heights and a power-law for vertical adjustement described in [25, Appendix B2]. Figure 8 shows the average annual wind speed at a resolution of 200m blocks at a hub height of 80 meters for the state of New York. Generic power curves for four representative classes of wind turbines (small residential, small commercial, midsize and large) were developed based on a survey of actual turbines' normalized power curves as described in [25, Appendix B3]. These power curves are to be updated .... Using wind speed data and assumed power curves for various wind turbine classes, hourly annual generation profiles can be created for each turbine at each location in the analysis.

POWER CURVES FOR WIND TURBINES HERE

2.4. Load Zones and Utility Territories

For this study all of the NYISO load zones and all of the larger utility territories were evaluated for their potential to site front-of-the-meter wind and the value of those exports to the grid. As municipal utilities are not required to offer VDER as a tariff/compensation mechanism,they were excluded from consideration. Figure 9 shows the major utility territories in the state of New York. Figure 10 shows the major NYISO load zones in the state

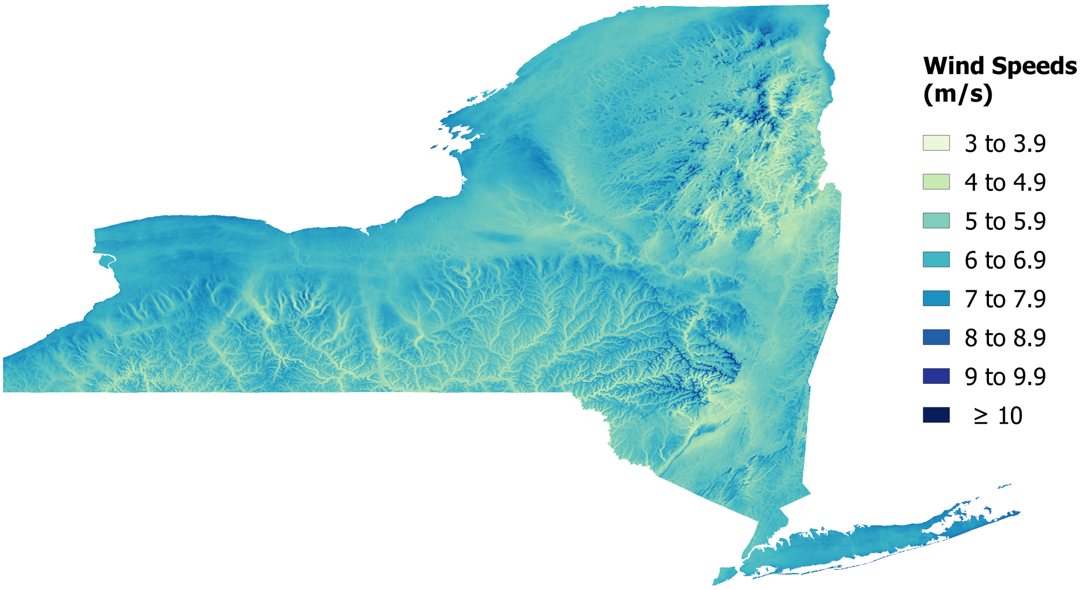


Figure 8: Average annual wind speeds at a hub height of 80m. Source: AWST [4].

of New York.[5]

2.5. Behind-the-meter Load and Net Energy Metering Considerations

ADDRESS HOW BTM LOAD AND NEM WERE ACCOUNTED FOR IN THE ANALYSIS

WHOLE SECTION NEEDS HEAVY REVIEW FOR ACCURACY

When determining the value of wind energy, behind-the-meter applications warrant two major additional considerations.

[5]Shapefiles of the utility territories and NYISO Load Zones used in this analysis were obtained from [7] and [14], respectively.

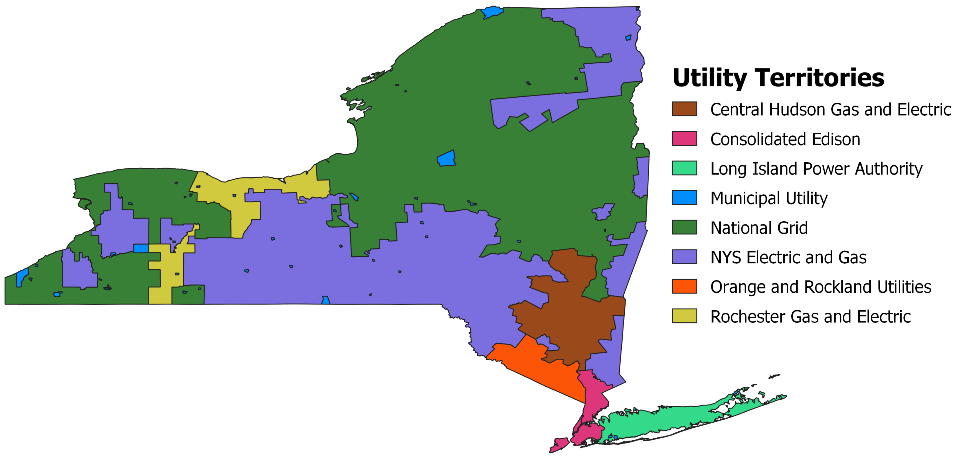


Figure 9: Major New York Utility Territories, with Municipal Utilities

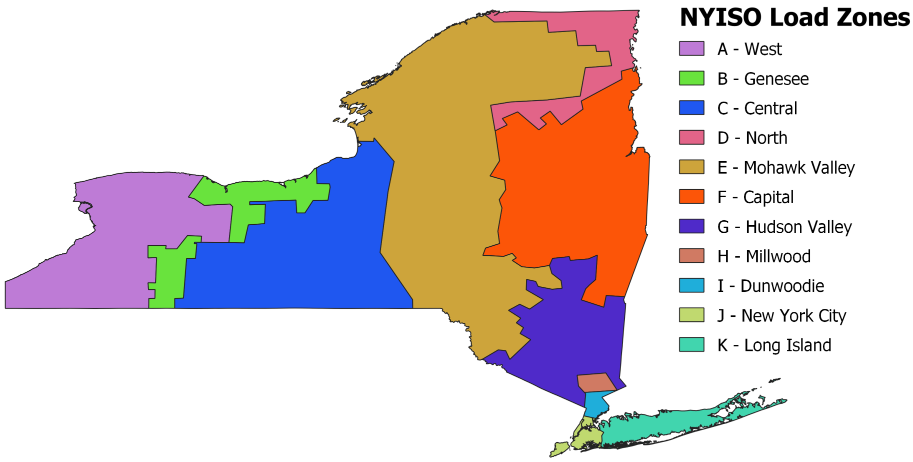


Figure 10: NYISO Load Zones

First, behind-the-meter customers typically install distributed generation systems in order to minimize their electricity bill.[6] This means customers will site systems not based on the largest system that could be sited on their property, but rather the system which minimizes their electricity bill. Determining the optimal sizing for a system to reduce bills depends on three factors: 1) the customer's retail tariff rate; 2) the customer's load profile; and 3) the wind resources at the customer's property. The retail tariff rate for behind-the-meter applications was assigned from the Utility Rate Database (URDB) based on which utility territory the behind-the-meter parcel was located and to which load sector the parcel's land use type belonged (Residential, Commercial, Industrial, Agricultural) (see Table A.1 in Appendix Appendix A) [**?**]. Table in Appendices of availabile tariff rates in New York by utility (at least those we considered) (might be good if we determined that distributed wind worked well for a particular customer class or tariff)? The customer's load profile was determined based on blah data set for the overall load shape and the parcel area size to scale up the generic load shape to the appropriate magnitude. Wind resource availability at the customer's site is determined as stated above in Section 2.3.

Second, behind-the-meter generation can qualify for an alternative compensation mechanism known as Net Energy Metering (NEM). Under NEM, all customer exports are credited at the retail tariff rate and can be used to offset consumption within the same (or future) billing cycles. Under NEM, both self-consumed generation and exported generation are worth the retail tariff rate for the customer in question [27].[7] This is different than under the VDER framework wherein exports are valued at the 'Value Stack' (detailed below) but onsite consumption is valued at the customer's retail rate as under NEM. As customers with distributed generation are eligible for both NEM and VDER, this analysis attempted to quantify the value of behind-the-meter wind applications across the state under both compensation mechanisms. In most cases, one would expect that NEM would be a more generous compensation mechanism than VDER as retail tariff rates are designed to recover both variable and fixed costs associated with delivering power that customer exports cannot reasonably offset. This means that customers under NEM would most often receive compensation in excess of the actual value of their exports, which is more accurately determined under the VDER framework.[8] In some locations and at specific times, however, it is possible that the VDER framework is more generous than the NEM framework as retail tariff rates (and therefore NEM compensation rates) typically are set to recover utility costs on an average, annual basis across a utility's entire territory. As discussed in Section 1.3, this geospatial and temporal averaging provides little information (or incentive) to customers and developers to change their demand patterns, distributed generation operating patterns

[6]In other contexts distributed generation could be primarily installed for power reliability, but in this analysis for the state of New York we consider the primary metric for installing and sizing systems to be financial returns through electricity bill reductions.

[7]This valuation can be complicated by retail tariff rates whose charges vary throughout time (e.g., under time-of-use rates).

[8]The authors are not suggesting that NEM is somehow an illegitimate compensation mechanism simply because it values distributed generation exports in excess of their real-time value. NEM has been successfully used throughout the United States and around the world as a tool to foster distributed generation markets in accordance with broader policy objectives that transcend a purely power-sector focused perspective.

or deployment patterns to maximize value to the power system.

2.6. *Valuation*

The following values were explored for this study:

- the Avoided Energy Value;
- the Avoided Capacity Investment Value;
- the Demand Reduction Value (DRV);
- the Locational System Relief Value (LSRV); and
- the Avoided Transmission and Distribution Losses Value.

NEED TO THINK ABOUT HOW THE METHODOLOGY AND ITS ASSOCIATED EXPLANATION CHANGE BETWEEN UTILITY SCALE AND DISTRIBUTED. ENERGY MAY BE RELATIVELY THE SAME (DAM PRICES), BUT WOULD CAPACITY BE DIFFERENT? NEED TO LOOK AT CAPACITY CREDIT USED FOR WIND TURBINES IN NEW YORK . . .

An explanation of what these values are intended to represent as well as the methodology used to determine the value follows. The methodology for these values were derived from NYSERDA's Value Stack Calculator as were input values, whenever possible. [19].

2.6.1. *Avoided Energy Value*

The Avoided Energy Value represents the variable costs, such as fuel costs or operating and maintenance costs, avoided by the distribution utility when injections of distributed energy offset generation from other units. Whenever a load-serving entity (LSE) seeks to satisfy demand, they typically use generating resources at their disposal in order of their associated variable costs, dispatching least-cost resources first, in order to meet demand as economically as possible. Because resources such as distributed wind and solar PV have no associated fuel costs, they are often the most economic choice for meeting demand when they are generating electricity. Thus exports from DERs will tend to either reduce the need for purchases from electricty markets or will offset generation from more expensive units within the utilitiy's generating fleet. In either case, the net effect of DER exports to the grid is to reduce costs associated with energy procurement for the utility. In the deregulated electricity market of New York, utilities do not own generation and instead purchase the bulk of their energy requirements on the Day Ahead Market (DAM), while using the Real Time Market (RTM) to address imbalances between actual and forecasted demand textscsource.

One way to quantify the net *energy* benefits associated DER exports is to measure its ability to reduce the purchases LSEs need to make from the electricity market by meeting demand locally. This is the approach within the Value Stack Calculator, and the Avoided

Energy Value is calculated as the hourly product of the exports to the grid from the DER and the day ahead market (DAM) price for the NYISO load zone in which the DER exports. For this analysis, the day ahead market prices for the year 2018 were taken from [16]. Table 11 shows the minimum, 25^{th} percentile, median, average, 75^{th} percentile, and maximum day ahead market energy prices for the year 2018 across the NYISO load zones considered in the analysis. Figure 12 also graphically shows the distribution of the energy proces. Figure 13 shows how the hourly product of the DER exports and the DAM prices are used to yield the Avoided Energy Value.

Zone	Min $/MWh	25^{th} $/MWh	Median $/MWh	Mean $/MWh	75^{th} $/MWh	Max $/MWh
Capital	11.07	25.13	31.48	37.80	40.14	315.24
Central	5.99	20.76	27.12	31.01	35.32	288.17
Dunwoodie	11.24	24.94	31.67	37.46	40.27	313.01
Genesee	5.15	20.09	26.23	29.88	34.23	277.48
Hudson Valley	11.18	24.76	31.35	36.92	39.78	314.17
Long Island	12.23	29.48	37.86	45.61	48.82	303.07
Millwood	11.22	24.93	31.58	37.22	40.09	314.75
Mohawk Valley	6.02	20.70	26.78	31.05	35.25	300.31
N.Y.C.	11.37	26.30	34.20	39.93	42.49	314.74
North	−2.91	14.83	20.22	24.29	29.28	281.24
West	5.97	20.47	26.99	32.37	36.28	283.84

Figure 11: Summary Statistics for 2018 NYISO Day Ahead Market Prices by Load Zone. Data Source: NYISO [16].

2.6.2. Avoided Capacity Investment Value

The Avoided Capacity Investment Value value broadly represents the costs avoided for utilities when DER can be reliably expected to help meet peak demand (which drives capacity needs), thereby reducing the capacity the utility must procure either by building their own generation capacity, or by procuring it from a capacity auction. Most of a customer's electricity bill, and therefore the utility's revenue recovery, is covered by a volumetric energy charge that varies with the consumption of power from the grid. However, many of the costs associated with providing a customer with power are fixed and depend on the customer's (or the power sytem's) instantaneous maximum demand (kW), rather than their total consumption (kWh). This is because a majority of the investments in the power system, from transmission and distribution lines to generating capacity must be sized in order to meet maximum demand. Thus a relatively small number of hours ultimately determine the fixed costs utilities must recover throughout a given year, and even longer as many power system investments have lifespans of several decades. Such fixed costs include, among others, the capital expenditures (CAPEX) required to build a new generating unit and the fixed operating and maintenance costs (FOM) associated with operating the unit.

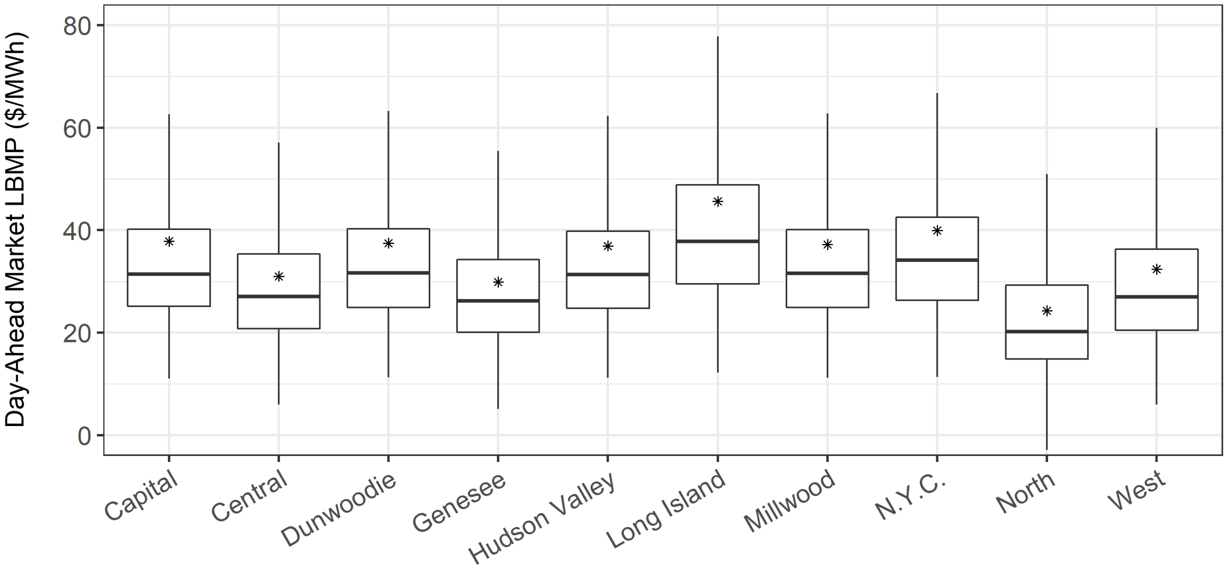


Figure 12: Boxplots of LBMP DAM Prices, maximum excluded, mean represented as star. Data Source: NYISO [16].

As New York is a deregulated energy market, the utilities procure generating capacity to meet their peak demand through capacity auctions, as opposed to building and operating the plants themselves. Accordingly, this analysis looks at the reduction in these capacity auction procurement requirements enabled by DER exports to determine the Avoided Capacity Investment Value. Generating capacity needs and capacity auction requirements are determined by the utilities by examining their forecasted highest periods of demand which occur in a small number of hours per year. As it is these select number of hours that contribute to peak demand and determine capacity auction requirements, only DER exports within these hours can actually provide capacity value by reducing utility purchases from the capacity market. This is accounted for in the VDER framework and this analysis by only allowing exports during certain hours to qualify for the Avoided Capacity Investment Value, defined as hours during which the entire NYISO territory is likely to experience peak demand. These hours are defined in the latest Value Stack Order as non-holiday weekdays from June 25th to August 31st for the hours between 2:00 PM and 6:00 PM, inclusive. Figure 14 below shows the valid hours during which DER exports could earn a capacity value for a typical week in July. Exports during these hours qualify for a value that is determined by the capacity auction for the NYISO load zone from which the DER is exporting.

WHICH METHOD IS THIS IN THE VDER STACK . . .

The specific value is calculated by taking the sum of the monthly capacity auction results

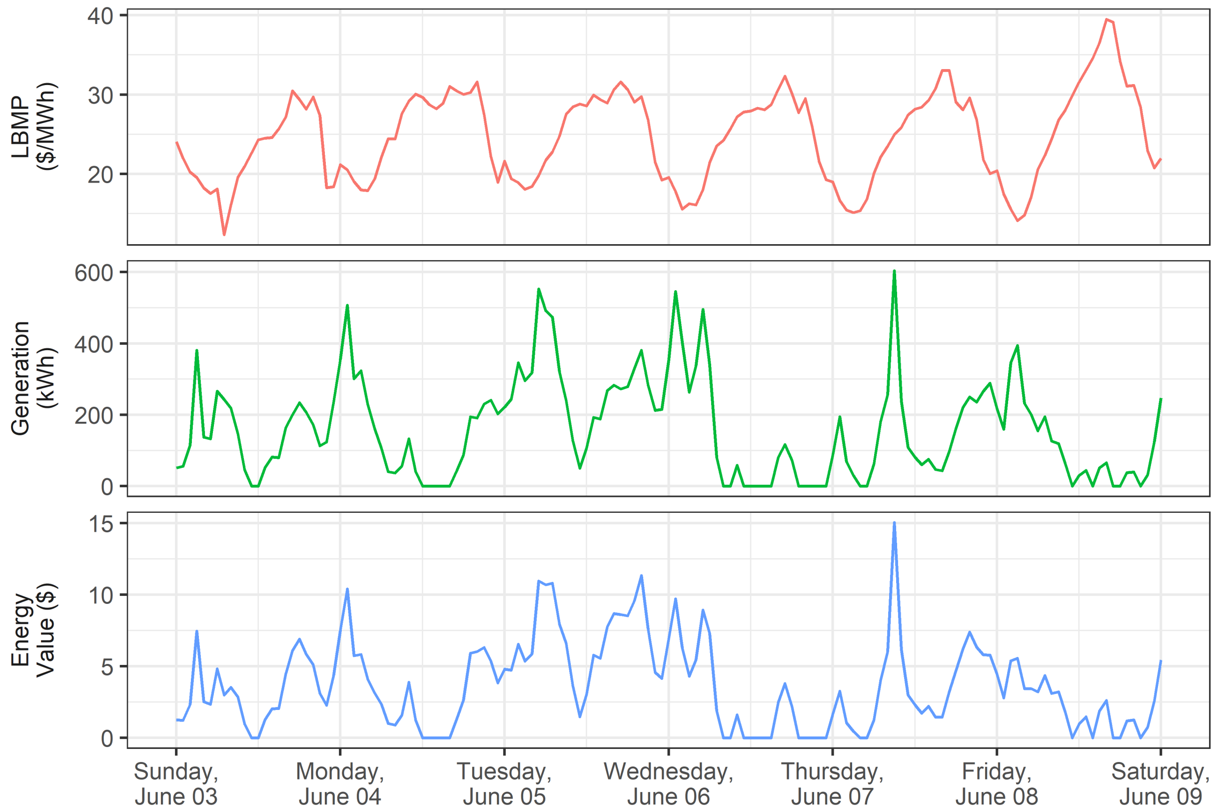


Figure 13: Example of Calculation of the Avoided Energy Value for a Representative Week in June for a Generator in the Hudson Valley NYISO Load Zone.

(in \$/kW-month) for an entire year (which yields \$/kW-year), measured from May 31st to May 31st. The monthly capacity auction results can be accessed at [15]. This annual capacity auction total (\$/kW-year) is divided by the number of qualifying hours in that year (from June 25th to August 31st on non-holiday weekdays from 2:00 PM to 6:00 PM), either 240 hours or 245 hours depending on whether Independence Day falls on a weekday during the year, to yield a capacity value in \$/kWh [19]. This value is expressed for each zone for three years from 2016 to 2018 in Table 15 and is shown graphically for the year 2018 in Figure 16. This value is then applied to all exports to the grid from the DER which occur in the valid hour window to calculate the Avoided Capacity Investment Value.

2.6.3. Demand Reduction Value

Similar to the Avoided Capacity Investment Value, the Demand Reduction Value is a measure of the ability of DER exports to reduce the overall infrastructure a utility must invest in, by reducing the load that utility must meet during peak periods. Rather than addressing the fixed costs associated with the generation fleet, however, the Demand Reduction Value expresses the value of reducing fixed costs associated with the transmission and distribution capacity needed to deliver power to customers. The infrastructure and associated costs for delivering power to customers varies strongly between and even within

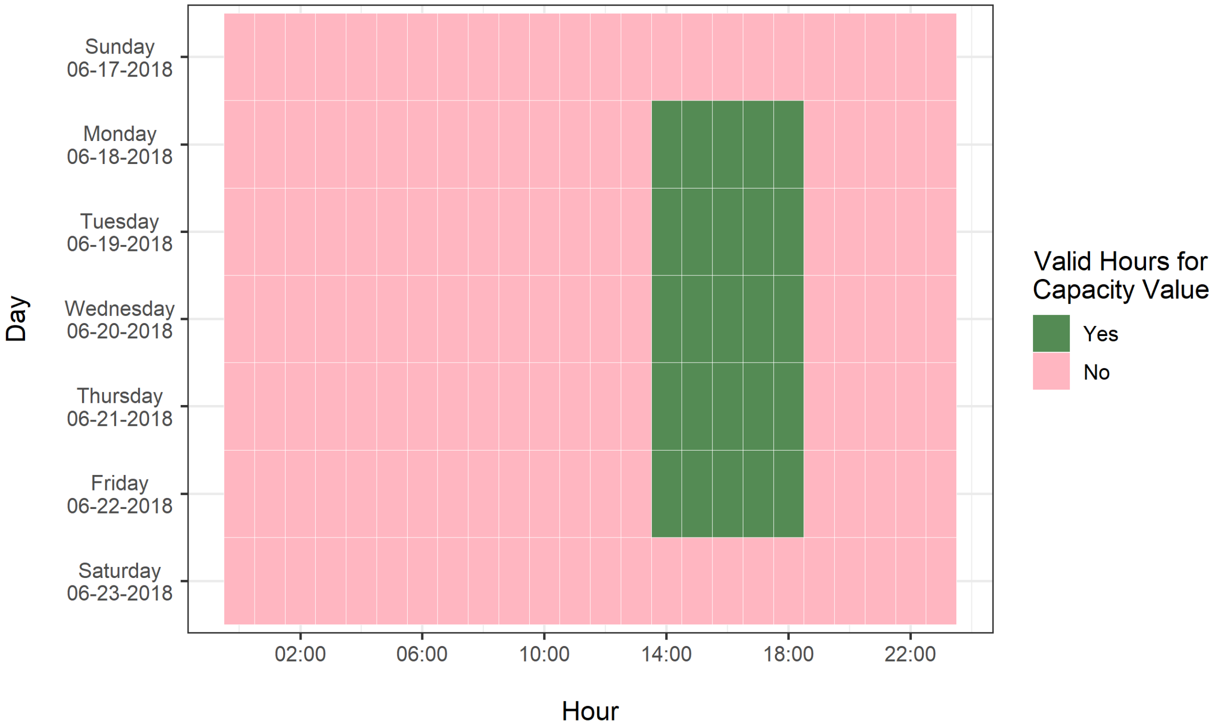


Figure 14: Valid Hours for DER Exports to Earn Capacity Value. Source: NYPSC [19].

Zone	2016 $/kWh	2017 $/kWh	2018 $/kWh
Long Island	0.161	0.197	0.209
N.Y.C.	0.398	0.325	0.314
West	0.137	0.082	0.089
Genesee	0.137	0.082	0.089
Central	0.137	0.082	0.089
North	0.137	0.082	0.089
Mohawk Valley	0.137	0.082	0.089
Capital	0.137	0.082	0.089
Hudson Valley	0.301	0.315	0.314
Millwood	0.301	0.315	0.314
Dunwoodie	0.301	0.315	0.314

Figure 15: Historical Normalized Capacity Auction Prices. Data Source: NYSERDA [21].

utilitiy territories and unlike generating capacity, there is no central auction for distribution and transmission capacity as this capacity cannot redistributed once built.

Accordingly, both the valid hours during which DER exports qualify for the Demand Reduction Value as well as the monetary value associated with exports are utility-specific.

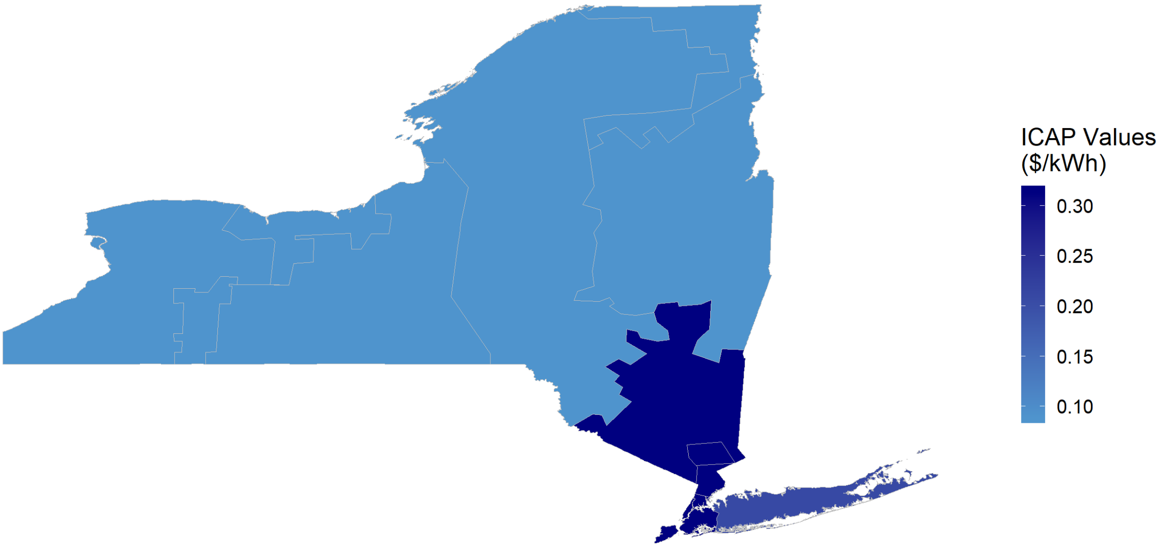


Figure 16: Chloropleth of ICAP Values by NYISO Load Zone. Data Source: NYSERDA [21]

For this analysis, the utility-specific valid hours and monetary value were taken directly from the Value Stack Order. The specific monetary value for exports is determined by each utility as part of its Marginal Cost of Service (MCoS) Study, although the methodology is set to be made more transparent and unified at a future date. Table 17 shows the relevant terms for the DRV calculation for each utility: the annual DRV value as well as the valid hours and dates for earning the DRV.

The monetary value for the Demand Reduction Value is given in terms of a fixed, 10-year $/kW-year rate. This value is converted to $/kWh by dividing ten times the annual value by the number of qualifying hours in that 10-year fixed term. Unlike the Avoided Energy Value and Avoided Capacity Investment Value, the Demand Reduction Value monetary value is set at a fixed rate for a 10 year period, rather than fluctuating month to month or hour to hour as with the day-ahead and capacity auction markets. The monetary value was fixed to help ensure a level of investor certainty for customers and renewable energy developers. As these projects require significant upfront capital to develop, investors must be certain than they can recuperate their sunk capital expenditures through revenues earned throughout the projects life. When this revenue fluctuates with energy and capacity markets, it better represents that distributed system's contribution to the power system, but it can be difficult to ensure cost recovery and may deter investment.

For Consolidated Edison, ConEd, rather than have a fixed DRV window for its entire territory, the utility divided its territory into four different, non-contiguous subsections based on each subsection's summer peak. Exports in each of these sections are awarded at the same value, but only qualify in different hours during the same June 24th to September 15th window. These subsections are reflected in Table 17 as well as in Figure 18. The subsections of the utility were determined by carefully comparing utility pdf maps of the subsections in their territory against publicly available maps of the various boroughs and neighborhoods in the Consolidated Edison territory [5]. SOURCE-MARGARET.[9]

$$Value_{DemandReduction}(i) = \sum_{\substack{t=0 \\ i \subseteq k \\ t \subseteq valid\ hours}}^{n} \underbrace{Export_{DER}(i,t)}_{\text{FOM wind generation}} \cdot \frac{\overbrace{DRV\ Price(k)}^{\text{Utility DRV \$ value}} \cdot 10}{\underbrace{n_{valid\ hours}}_{\text{number of valid hours in 10 year period}}} \quad (1)$$

Utility	Annual Value $/kW-year	Hour Window non-holiday	Date Window weekend hours	DRV Value $/kWh
ConEd* -				
A	199.4	11:00 - 15:00	June 24 - September 15	0.854
B	199.4	14:00 - 18:00	June 24 - September 15	0.854
C	199.4	16:00 - 20:00	June 24 - September 15	0.854
D	199.4	19:00 - 23:00	June 24 - September 15	0.854
ORU	64.78	14:00 - 19:00	June 24 - September 15	0.222
CHEG	14.55	14:00 - 19:00	June 24 - September 15	0.050
NGrid	61.44	14:00 - 19:00	June 24 - September 15	0.210
RGE	31.92	14:00 - 19:00	June 24 - September 15	0.109
NYSEG** -				
Summer	29.67	14:00 - 19:00	June 24 - September 15	0.089
Winter	29.67	17:00 - 19:00	January 1 - January 31	0.089
LIPA	109.86	14:00 - 19:00	June 1 - August 31	0.338

Figure 17: DRV Values and Time Windows for NY Utilities.
*:Consolidated Edison, or ConEd, chose to divide its utility territory into four different, non-contiguous subsections based on each subsection's summer peak. Exports in each of these sections are awarded at the same value, but only qualify in different hours during the same June 24$^{\text{th}}$ to September 15$^{\text{th}}$ window.
**: New York State Electricity and Gas utility has two distinct peaks in its territory, one in the summer and one in the winter. In order to incentivize exports to reduce both peaks, the utility offers a DRV bonus in the summer and winter. $/kWh values are still calculated by dividing ten times the annual amount by the number of qualifying hours over a ten-year period. Source: NYPSC [19].

map zoomed in of ConEdison DRV zones

2.6.4. Locational System Relief Value

The Locational System Relief Value measures the value of a DER's export to reduce congestion at specific points within the power system by injecting power near demand. This value is limited not only to injections within specific time periods, but also to specific

[9] The utility maps actually display the Commercial System Relief Program (CSRP) areas in their territory, which were also used when creating the DRV subsections in their territory [19].

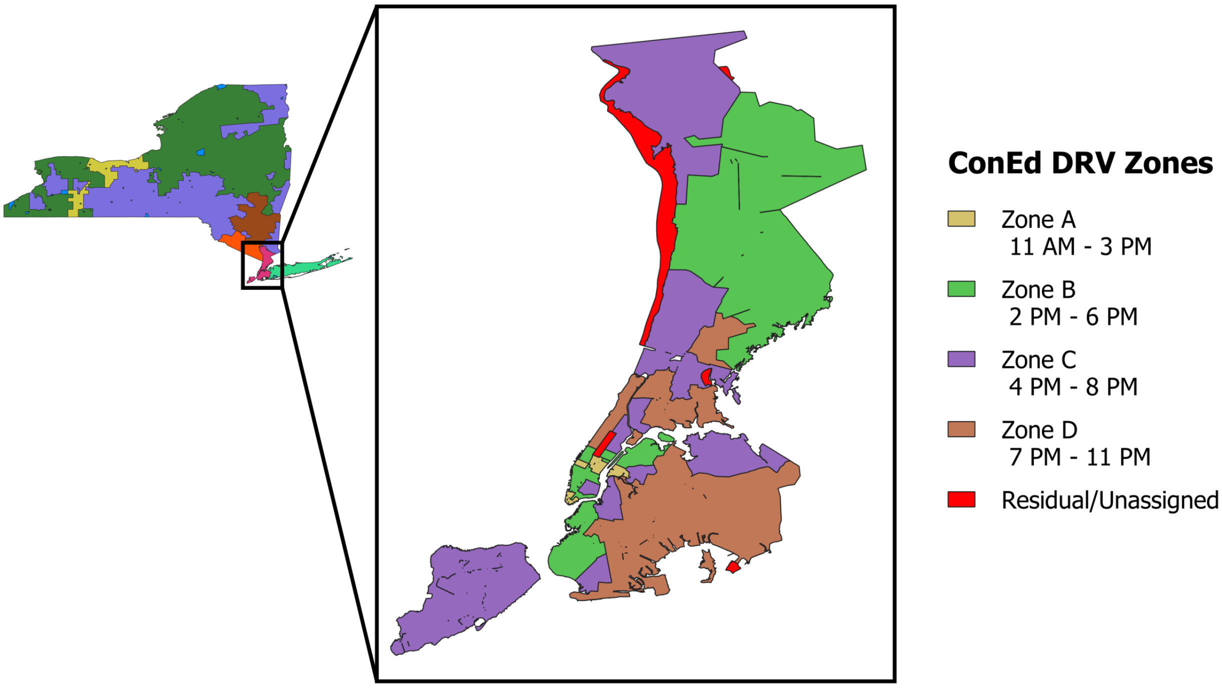


Figure 18: The DRV Subsections of the Consolidated Edison Utility Territory. Source: source-Margaret

subsections of the power system. Utilities have identified portions of their territory that experience significant congestion during their territory's peak period that could benefit from more local generation. Only exports originating from within these 'LSRV zones' can qualify for LSRV compensation. Figure 19 highlights an example of an LSRV zone in the Long Island Power Authority Territory.

Unlike the DRV or Avoided Capacity Investment Value, the time periods during which exports qualify are determined dynamically by the utilities themselves through 'calls'. Utilities must alert generators of such calls twenty-one hours in advance of the actual call. Utilities are required to make at least 10 calls per year and each call must be at least 1 hour in duration and no more than 4 hours in duration. As a default the hours, during which a call could be made are the same hours for the DRV value, however, utilities have the option of setting separate/unique LSRV hours distinct form the DRV window based on 'sub-system peaks'. Table 20 shows the the annual LSRV value, where the the valid hours and dates for earning the LSRV are assumed to be the same as the DRV. The LSRV Value ($/kW-call) is derived based on the minimum 10 calls/year quota set by the NYPSC. Although a minimum of 10 calls must be made per year, it is possible for the utility to make additional calls, which means that generators could theoretically earn more than the annual LSRV value.

Also dissimilar to the DRV, only the minimum instantaneous generation within the given call is applied to the $4/kw-call value for the duration of the call (e.g. if a generator exported 4 kW, 10 kW, 15 kW and 7 kW within a 4 hour call, the export magnitude used to determine the LSRV value in each hour would be 4 kW and the total LSRV value for that call would be $4kW * Call - value_L SRV$). As with the DRV, the monetary value for the LSRV is given

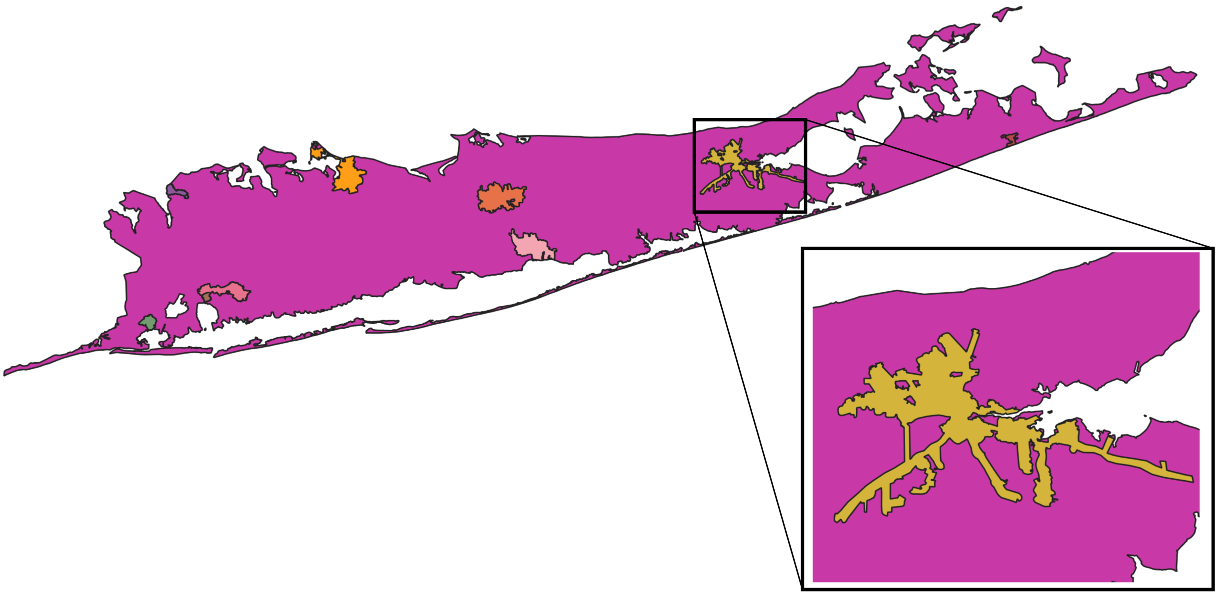


Figure 19: Long Island Power Authority LSRV Zones with focus on Specific Zone.

Utility	Annual Value $/kW-year	LSRV Value $/kW-call
ConEd - Winchester	140.76	14.076
ConEd - N.Y.C.	140.76	14.076
ORU	39.61	3.961
CHEG	0	0.000
NGrid	30.72	3.072
RGE	47.96	4.796
NYSEG		
- New York Area	53.96	5.396
- Lower Hudson	56.26	5.626
LIPA	54.93	5.493

Figure 20: LSRV Values and Time Windows for NY Utilities

in $/kW-year and must be converted by dividing by 10 (for each call) yielding $/kW-call. The monetary value can be unique within each utility territory.

Need to add something about how the LSRV $ values are actually determined, i.e. explain the Marginal Cost of Service studies and cite ConEd's report by Brattle ...

2.6.5. Avoided Transmission and Distribution Losses Value

Need to check and see which losses are being applied to which value & utility territory. It appears that only the energy and capacity value qualify for the scale-up, see the losses and factors of adjustment in the calaculator on the 'Losses' sheet ...

When utilities deliver energy from large, centralized generators in order to meet customer demand, that delivery suffers from losses on both the transmission system and distribution system. These losses have a vareity of causes, such as resistive 'skin' losses or 'corona' losses caused by sufficiently high line-to-line voltages, but in general the longer the distance energy must travel between generating source and the demand sink, the higher the losses the energy will experience. Compared to satisfying demand from centralized generating resources, meeting customer demand with generators located nearby on the distribution system suffers fewer losses. This is particularly true in the case of behind-the-meter systems satisfying onsite customer demand. To account for these reduced losses, the Avoided Energy Value and the Avoided Capacity Investment Value should be scaled up by the appropriate transmission and distribution (T&D) losses. This is because less energy is ultimately required from distributed assets than centralized assets to meet demand, while the same amount of distributed capacity can meet more peak demand than centralized assets (assuming the DER exports occur during the appropriate periods of peak demand). Table 21 shows the published losses for each utility territory as used in NYSERDA [21] as well as the Factor of Adjustment (FOA) that is determined based on the losses and is used to scale up the Avoided Energy Value and the Avoided Capacity Investment Value.

2.6.6. Limits of Methodology

- Does not consider technical limitations of interconnecting at feeder
  - Allen [2], Martinez-Anido and Hodge [12]
- Does not consider costs of upgrading distr. systems to accomodate more wind
- Does not consider fluctuating losses
- siting and sizing limitations?

	Transmission		Distribution		T&D	
Utility Territory	Losses	FOA	Losses	FOA	Losses	FOA
CHEG	0.606%	1.0061	1.966%	1.0201	2.572%	1.0264
ConEd	5.900%	1.0630	4.700%	1.0493	5.900%	1.0627
NGrid	2.057%	1.0210	5.692%	1.0604	7.749%	1.0840
NYSEG	0.000%	1.0000	6.786%	1.0728	6.786%	1.0728
ORU	2.483%	1.0255	4.913%	1.0517	7.396%	1.0799
LIPA	0.000%	1.0000	6.271%	1.0669	6.271%	1.0669
RGE	4.680%	1.0491	1.800%	1.0183	6.480%	1.0693

Figure 21: Utility Transmission and Distribution Losses and Asspciated Factor of Adjustment (FOA) Used to Scale-up Values. Source: NYSERDA [21].

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Appendix A. Land Use Type to Application Mapping

Table A.1 shows how land use types from the CoreLogics dataset were mapped to different applications. The table also shows what load patterns were mapped to which parcel which was used when determining the overall value under the VDER and NEM frameworks for behind-the-meter wind turbines (see Section 2.5). These load patterns were based off of the blah blah data set, cite. Although ultimately a subjective decision, one application was attempted to be mapped to a land use type.

Table A.1: Mapping Between CoreLogics Dataset and Load Shapes and Applications

Land Use Type	Load Shape	Eligible Applications	Load Sector
agricultural (nec)	warehouse	BTM, FOM, Utility	Agricultural
agricultural land	warehouse	BTM, FOM, Utility	Agricultural
aircraft facility	high-energy	BTM, FOM	Industrial
airport	high-energy	BTM, FOM	Industrial
amusement arcade	stand-alone-retail	BTM	Commercial
amusement park	large-office	BTM, FOM	Commercial
animal farm	warehouse	BTM, FOM, Utility	Agricultural
animal hospital, vet	hospital	BTM	Commercial
apartment	midrise-apartment	BTM	Residential
apartment, hotel	large-hotel	BTM, FOM	Commercial
auditorium	stand-alone-retail	BTM	Commercial
auto repair	stand-alone-retail	BTM	Commercial
auto sales	stand-alone-retail	BTM	Commercial
bar	full-service-restaurant	BTM	Commercial
bowling alley	stand-alone-retail	BTM	Commercial
brewery	full-service-restaurant	BTM	Commercial
cabin	small-hotel	BTM	Residential
carwash	stand-alone-retail	BTM	Commercial

cemetery	low-energy	BTM, FOM	Residential
charitable organization	medium-office	BTM	Commercial
chemical	warehouse	BTM	Industrial
club	medium-office	BTM	Commercial
commercial (nec)	warehouse	BTM, FOM	Commercial
commercial acreage	warehouse	BTM, FOM	Commercial
commercial building	warehouse	BTM, FOM	Commercial
commercial condominium	small-hotel	BTM	Residential
commercial lot	medium-office	BTM, FOM, Utility	Commercial
common area	low-energy	BTM, FOM, Utility	Commercial
common land	low-energy	BTM, FOM, Utility	Commercial
communication facility	medium-office	BTM, FOM	Commercial
community center	medium-office	BTM	Commercial
condominium	midrise-apartment	BTM	Residential
convalescent hospital	hospital	BTM, FOM	Commercial
converted residence	small-hotel	BTM	Residential
cooperative	medium-office	BTM, FOM	Commercial
correctional facility	large-office	BTM, FOM	Commercial
country club	stand-alone-retail	BTM, FOM	Commercial
county property	low-energy	BTM, FOM, Utility	Commercial
dairy farm	warehouse	BTM, FOM, Utility	Agricultural
department store	stand-alone-retail	BTM	Commercial

drive in theater	stand-alone-retail	BTM, FOM	Commercial
duplex	small-hotel	BTM	Residential
easement	low-energy	BTM, FOM	Commercial
educational service	secondary-school	BTM, FOM	Commercial
electrical facility	medium-office	BTM, FOM	Commercial
embassies, chanceries	small-hotel	BTM	Commercial
farms	warehouse	BTM, FOM, Utility	Agricultural
fast food franchise	quick-service-restaurant	BTM	Commercial
federal building	large-office	BTM	Commercial
federal property	low-energy	BTM, FOM, Utility	Commercial
field & seed	low-energy	BTM, FOM, Utility	Commercial
financial building	large-office	BTM	Commercial
fisheries	warehouse	BTM, FOM, Utility	Agricultural
food processing	high-energy	BTM, FOM	Commercial
food stores	supermarket	BTM	Commercial
forest	low-energy	BTM, FOM, Utility	Agricultural
frat, sorority house	small-hotel	BTM	Party
funeral home	small-office	BTM	Commercial
garage	stand-alone-retail	BTM	Commercial
gas production	high-energy	BTM, FOM	Commercial
golf course	low-energy	BTM, FOM	Commercial
greenhouse	medium-office	BTM, FOM	Commercial
group quarters	small-hotel	BTM	Residential
gymnasium	secondary-school	BTM	Commercial
health club	small-office	BTM	Commercial
heavy industrial	high-energy	BTM, FOM	Industrial

hospital	hospital	BTM, FOM	Commercial
hotel	large-hotel	BTM	Commercial
industrial (nec)	high-energy	BTM, FOM	Industrial
industrial acreage	warehouse	BTM, FOM, Utility	Industrial
industrial lot	warehouse	BTM, FOM, Utility	Industrial
industrial plant	high-energy	BTM, FOM	Industrial
kennel	small-office	BTM	Commercial
lake, river, beach	low-energy	BTM, FOM, Utility	Commercial
laundromat	stand-alone-retail	BTM	Commercial
library, museum	secondary-school	BTM	Commercial
light industrial	high-energy	BTM, FOM	Industrial
livestock	warehouse	BTM, FOM, Utility	Agricultural
loft building	small-office	BTM	Commercial
lumber mill	high-energy	BTM, FOM, Utility	Industrial
lumber yard	warehouse	BTM, FOM, Utility	Industrial
manufactured home	small-hotel	BTM	Residential
marina facility	medium-office	BTM, FOM	Commercial
marine facility	low-energy	BTM, FOM	Commercial
marshland	low-energy	BTM, FOM, Utility	Agricultural
medical building	hospital	BTM, FOM	Commercial
military building	large-office	BTM, FOM	Commercial
mine, quarry	warehouse	BTM, FOM, Utility	Industrial
mineral processing	warehouse	BTM, FOM	Industrial
mini warehouse	warehouse	BTM	Commercial
misc building	medium-office	BTM	Commercial
misc commercial services	medium-office	BTM	Commercial

miscellaneous	medium-office	BTM	Commercial
mobile home	small-hotel	BTM	Residential
mobile home park	small-hotel	BTM	Residential
motel	small-hotel	BTM	Residential
multi family dwelling	small-hotel	BTM	Residential
multiple uses	medium-office	BTM	Commercial
municipal property	low-energy	BTM, FOM	Commercial
native american property	low-energy	BTM, FOM, Utility	Commercial
nightclub	stand-alone-retail	BTM	Commercial
nursery school	primary-school	BTM	Commercial
nursery, horticulture	stand-alone-retail	BTM	Commercial
nursing home	small-hotel	BTM	Residential
office & residential	medium-office	BTM	Commercial
office building	medium-office	BTM	Commercial
office condo	medium-office	BTM	Commercial
orchard	warehouse	BTM, FOM, Utility	Agricultural
orphanage	secondary-school	BTM	Commercial
paper & allied industry	high-energy	BTM, FOM, Utility	Industrial
park	low-energy	BTM, FOM	Commercial
parking lot	low-energy	BTM, FOM	Commercial
parking structure	low-energy	BTM, FOM	Commercial
petroleum	high-energy	BTM, FOM, Utility	Industrial
police, fire, civil defense	medium-office	BTM, FOM	Commercial
poultry ranch	warehouse	BTM, FOM, Utility	Agricultural

private school	secondary-school	BTM	Commercial
public (nec)	low-energy	BTM, FOM	Commercial
public school	secondary-school	BTM	Commercial
public service	medium-office	BTM, FOM	Commercial
quadruplex	small-hotel	BTM	Residential
r&d facility	large-office	BTM, FOM	Commercial
race track	large-office	BTM, FOM	Commercial
radio facility	small-office	BTM	Commercial
railroad facility	warehouse	BTM, FOM, Utility	Industrial
recreational (nec)	warehouse	BTM, FOM, Utility	Industrial
religious	small-office	BTM	Commercial
residence hall, dormitories	small-hotel	BTM	Residential
residential (nec)	small-hotel	BTM	Residential
residential acreage	small-hotel	BTM	Residential
residential lot	small-hotel	BTM	Residential
resort hotel	large-hotel	BTM, FOM	Commercial
restaurant building	full-service-restaurant	BTM	Commercial
restaurant drive in	quick-service-restaurant	BTM	Commercial
retail trade	strip-mall	BTM	Commercial
rural homesite	small-hotel	BTM	Residential
salvage imprv	low-energy	BTM, FOM	Commercial
school	secondary-school	BTM	Commercial
service station	stand-alone-retail	BTM	Commercial
service station, market	stand-alone-retail	BTM	Commercial
sfr	small-hotel	BTM	Residential
shopping center	strip-mall	BTM	Commercial

skating rink	stand-alone-retail	BTM	Commercial
stable	low-energy	BTM, FOM	Agricultural
stadium	high-energy	BTM, FOM	Commercial
state property	low-energy	BTM, FOM, Utility	Commercial
storage	warehouse	BTM, FOM	Commercial
storage tanks	warehouse	BTM, FOM	Commercial
store building	stand-alone-retail	BTM	Commercial
stores & offices	stand-alone-retail	BTM	Commercial
stores & residential	small-hotel	BTM	Residential
strip commercial center	strip-mall	BTM, FOM	Commercial
supermarket	supermarket	BTM	Commercial
swimming pool	stand-alone-retail	BTM	Commercial
tavern	full-service-restaurant	BTM	Commercial
tax exempt	low-energy	BTM, FOM	Commercial
technological industry	high-energy	BTM, FOM, Utility	Industrial
telephone facility	medium-office	BTM, FOM	Commercial
tennis club	medium-office	BTM, FOM	Commercial
theater	stand-alone-retail	BTM	Commercial
tourist attraction, exhibits	low-energy	BTM	Commercial
townhouse, row-house	small-hotel	BTM	Residential
transient lodging	small-hotel	BTM	Residential
transport (nec)	medium-office	BTM, FOM	Commercial
transport facility	medium-office	BTM, FOM	Commercial
triplex	small-hotel	BTM	Residential

truck crops	medium-office	BTM, FOM	Commercial
truck terminal	medium-office	BTM, FOM	Commercial
tv facility	medium-office	BTM, FOM	Commercial
university	secondary-school	BTM, FOM	Commercial
us postal service	small-office	BTM	Commercial
utilities	medium-office	BTM, FOM	Commercial
vacant land (nec)	low-energy	BTM, FOM	Commercial
vacant lmtd, no dev potential	low-energy	BTM, FOM	Commercial
vineyard	low-energy	BTM, FOM	Agricultural
vocational, trade school	secondary-school	BTM, FOM	Commercial
warehouse	warehouse	BTM, FOM	Commercial
waste disposal	high-energy	BTM, FOM	Commercial
well, gas, oil	warehouse	BTM, FOM, Utility	Industrial
well, water	low-energy	BTM, FOM	Commercial
wholesale	warehouse	BTM, FOM	Commercial
winery	low-energy	BTM, FOM	Agricultural